IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant	: Mei Chen	Art Unit	: 2609
Serial No.	: 10/763,791	Examiner	: Tsai, Tsung Yin
Filed	: Jan. 23, 2004	Confirmation No.	: 7930
Title	: STABILIZING A SEQUENCE OF IMAGE FRAMES		

Commissioner for Patents
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APPEAL BRIEF

I. Real Party in Interest

The real party in interest is Hewlett-Packard Development Company, L.P., a Texas Limited Partnership having its principal place of business in Houston, Texas.

II. Related Appeals and Interferences

Appellant is not aware of any related appeals or interferences that will directly affect or be directly affected by or have a bearing on the Board's decision in the pending appeal.

III. Status of Claims

Claims 1-9, 11-19, and 21-29, which are the subject of this appeal, are pending.

Claims 10, 20, and 30 have been canceled.

Claims 1-9, 11-19, and 21-29 stand rejected.

Appellant appeals all rejections of the pending claims 1-9, 11-19, and 21-29.

CERTIFICATE OF TRANSMISSION

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IV. Status of Amendments

The amendments filed June 1, 2007, have been entered and acted upon by the Examiner. No amendments were filed after the final Office action dated October 5, 2007.

V. Summary of Claimed Subject Matter

A. Independent claim 1

The aspect of the invention defined in independent claim 1 is a machine-implemented method of processing a sequence of image frames (page 3, lines 23-26; FIG. 1). In accordance with this method, respective sets of motion vectors are computed for pairs of the image frames (page 4, lines 17-18). The computed motion vectors are classified into motion classes (page 5, lines 26-29). Motion clusters are identified in the image frames based at least in part on the motion classes (page 6, lines 5-31; FIG. 3). A respective spatiotemporal consistency value indicating persistence of the motion cluster in a respective spatial region across neighboring ones of the image frames is determined for each of the identified motion clusters (page 7, lines 15-31; FIG. 4). One of the identified motion clusters is selected as a motion stabilization reference based on the spatiotemporal consistency values (page 9, lines 25-33). A motion model describing motion of the motion stabilization reference in the image frame sequence is determined (page 10, lines 5-21). A motion-stabilized version of the sequence of image frames is produced based on the motion model (page 10, lines 5-29; FIG. 7).

B. Dependent claim 6

Claim 6 depends from claim 4 and recites that ones of the motion vectors are re-classified with a modified clustering parameter in response to a determination that the respective spatiotemporal consistency values are below a consistency threshold (page 9, lines 9-14).

C. Dependent claim 7

Claim 7 depends from claim 3 and recites that motion vectors are clustered iteratively in accordance with a clustering method (page 6, lines 5-19; page 8, lines 24-27; FIGS. 5, 6A, and 6B).

D. Dependent claim 8

Claim 8 depends from claim 1 and recites that the selecting comprises projecting each motion cluster from image frames to respective neighboring image frames (page 7, lines 15-17), and computing respective measures of spatiotemporal consistency for the projected motion clusters (page 7, lines 17-19).

E. Dependent claim 9

Claim 9 depends from claim 1 and recites that the selecting comprises selecting as the motion stabilization reference for a given reference image frame the motion cluster having a greater spatiotemporal consistency value than the spatiotemporal consistency values of other ones of the motion clusters across multiple image frames neighboring the given reference image frame (page 9, lines 28-30).

F. Independent claim 11

The aspect of the invention defined in independent claim 11 is a system for processing a sequence of image frames (page 3, lines 23-26; FIG. 1). The system includes a motion estimation module, a motion classification module, a motion-based spatial clustering module, a motion stabilization reference selection module, and a motion stabilization module (page 3, lines 23-26; FIG. 1). The motion estimation module is configured to compute respective sets of motion vectors for pairs of image frames (page 4, lines 17-18). The motion classification module is configured to classify the computed motion vectors into motion classes (page 5, lines 26-29). The motion-based spatial clustering module is configured to identify motion clusters in

the image frames based at least in part on the motion classes (page 6, lines 5-31; FIG. 3). The motion-based spatial clustering module also is configured to determine for each of the identified motion clusters a respective spatiotemporal consistency value indicating persistence of the motion cluster in a respective spatial region across neighboring ones of the image frames (page 7, lines 15-31; FIG. 4). The motion stabilization reference selection module is configured to select one of the identified motion clusters as a motion stabilization reference based on the spatiotemporal consistency values (page 9, lines 25-33). The motion stabilization module is configured to determine a motion model describing motion of the motion stabilization reference in the image frame sequence (page 10, lines 5-21). The motion stabilization module also is configured to produce a motion-stabilized version of the sequence of image frames based on the motion model (page 10, lines 5-29; FIG. 7).

G. Dependent claim 16

Claim 16 depends from claim 14 and recites that the motion classification module re-classifies ones of the motion vectors with a modified clustering parameter in response to a determination that the respective spatiotemporal consistency values are below a consistency threshold (page 9, lines 9-14).

H. Dependent claim 17

Claim 17 depends from claim 13 and recites that the motion classification module clusters motion vectors iteratively in accordance with a clustering method (page 6, lines 5-19; page 8, lines 24-27; FIGS. 5, 6A, and 6B).

I. Dependent claim 18

Claim 18 depends from claim 11 and recites that the motion stabilization reference selection module selects a motion cluster as the motion stabilization reference by projecting each motion cluster from image frames to respective neighboring image frames (page 7, lines 15-17), and computing respective measures of spatiotemporal consistency for the projected motion clusters (page 7, lines 17-19).

J. Dependent claim 19

Claim 19 depends from claim 11 and recites that the motion stabilization reference selection module selects as the motion stabilization reference for a given reference image frame the motion cluster having a greater spatiotemporal consistency value than the spatiotemporal consistency values of other ones of the motion clusters across multiple image frames neighboring the given reference image frame (page 9, lines 28-30).

K. Independent claim 21

The aspect of the invention defined in independent claim 21 is a machine-readable medium storing machine-readable instructions for causing a machine to perform operations (page 11, lines 1-19). The machine-readable instructions cause the machine to compute respective sets of motion vectors for pairs of image frames (page 4, lines 17-18). The machine-readable instructions cause the machine to classify the computed motion vectors into motion classes (page 5, lines 26-29). The machine-readable instructions cause the machine to identify motion clusters in the image frames based at least in part on the motion classes (page 6, lines 5-31; FIG. 3). The machine-readable instructions cause the machine to determine for each of the identified motion clusters a respective spatiotemporal consistency value indicating persistence of the motion cluster in a respective spatial region across neighboring ones of the image frames (page 7, lines 15-31; FIG. 4). The machine-readable instructions cause the machine to select one of the identified motion clusters as a motion stabilization reference based on the spatiotemporal consistency values (page 9, lines 25-33). The machine-readable instructions cause the machine to determine a motion model describing motion of the motion stabilization reference in the image frame sequence (page 10, lines 5-21). The machine-readable instructions cause the machine to produce a motion-stabilized version of the sequence of image frames based on the motion model (page 10, lines 5-29; FIG. 7).

L. Dependent claim 26

Claim 26 depends from claim 24 and recites that the machine-readable instructions cause the machine to re-classify ones of the motion vectors with a modified clustering parameter in

response to a determination that the respective spatiotemporal consistency values are below a consistency threshold (page 9, lines 9-14).

M. Dependent claim 27

Claim 27 depends from claim 23 and recites that the machine-readable instructions cause the machine to cluster motion vectors iteratively in accordance with a clustering method (page 6, lines 5-19; page 8, lines 24-27; FIGS. 5, 6A, and 6B).

N. Dependent claim 28

Claim 28 depends from claim 21 and recites that the machine-readable instructions cause the machine to select a motion cluster as the motion stabilization reference by projecting each motion cluster from image frames to respective neighboring image frames (page 7, lines 15-17), and computing respective measures of spatiotemporal consistency for the projected motion clusters (page 7, lines 17-19).

O. Dependent claim 29

Claim 29 depends from claim 21 and recites that the machine-readable instructions cause the machine to select as the motion stabilization reference for a given reference image frame the motion cluster having a greater spatiotemporal consistency value than the spatiotemporal consistency values of other ones of the motion clusters across multiple image frames neighboring the given reference image frame (page 9, lines 28-30).

VI. Grounds of Rejection to be Reviewed on Appeal

A. Claims 1, 11, and 21 stand rejected under 35 U.S.C. § 102(b) over Wang (U.S. 5,557,684).

B. The Examiner has rejected claims 8, 9, 18, 19, 28, and 29 under 35 U.S.C. § 103(a) over Wang in view of Heisele ("Motion-based object detection and tracking in color image sequence").

C. The Examiner has rejected claims 2-6, 12-16, and 22-26 under 35 U.S.C. § 103(a) over Wang in view of Ohm ("Feature-based cluster segmentation of image sequences").

D. The Examiner has rejected claims 7, 17, and 27 under 35 U.S.C. § 103(a) over Wang in view of Ohm and Heisele.

VII. Argument

A. Claims 1, 11, and 21 stand rejected under 35 U.S.C. § 102(b) over Wang (U.S. 5,557,684)

The Examiner has rejected claims 1, 11, and 21 under 35 U.S.C. § 102(b) over Wang (U.S. 5,557,684).

1. Applicable standards for sustaining a rejection under 35 U.S.C. § 102(b)

The relevant part of 35 U.S.C. § 102(b) recites that "A person shall be entitled to an invention, unless - … the invention was patented or described in a printed publication in this or a foreign country or in public use or on sale in this country, more than one year prior to the date of the application for patent in the United States." Anticipation under 35 U.S.C. § 102(b) requires that each and every element of the claimed invention be present, either expressly or inherently, in a single prior art reference. EMI Group N. Am., Inc., v. Cypress Semiconductor Corp., 268 F.3d 1342, 1350 (Fed. Cir. 2001). Anticipation must be proved by clear and convincing evidence. Electro Medical Systems, S.A. v. Cooper Life Sciences, Inc., 34 F3d 1048, 1052 (Fed. Cir. 1994).

2. Overview of Wang's disclosure

In accordance with Wang's disclosure, his "… invention relates generally to image coding, and in particular, to a mechanism for compressing image data for storage, transmission and decoding" (col. 1, lines 10-12). In particular, Wang discloses a system for encoding an image sequence into multiple layers each of which represents a respective region of coherent motion and associated motion parameters. The layers are ordered by depth in the image, and

each layer includes information describing how the layer should be manipulated or transformed over time (see, e.g., col. 1, lines 19-25). The image sequence is recreated (or decoded) by combining the layers in order and warping them over time (see, e.g., col. 1, lines 40-43).

The system 12 includes a local motion estimator 22, a coherent motion region estimator 24a, and a motion estimator 24b (see FIG. 3). The local motion estimator 22 estimates movements of local pixel areas between consecutive frames (see col. 5, lines 16-31). The coherent motion region estimator 24a identifies regions of coherent motion from an analysis of the motions associated with neighboring frames with arbitrary non-overlapping regions used for analysis of the first pair of frames in the sequence (see col. 5, lines 37-38, and col. 10, lines 4-7). The motion estimator 24b produces a motion model for each of the identified regions of coherent motion, groups similar models, and produces a composite motion model for each group (see col. 5, lines 35-42). The coherent motion region estimator 24a associates individual pixels with the composite motion models (see col. 5, lines 43-50). The motion model parameters and information identifying the coherent motion regions are stored (see col. 5, lines 51-55). This process is repeated for each frame pair (see col. 5, line 61 - col. 6, line 7).

Wang discloses that "A layer extraction processor 26 combines the coherent region information and the associated motion model information for all the frames and produces one layer for each region" (col. 6, lines 8-11). The system 12 then produces a layer intensity map from composite pixel intensity values for every pixel location within each region (see col. 6, lines 21-25). The processor 26 sends the layer information to a data storage and/or transmission device for storage and/or transmission. Wang discloses that "A sequence of 30 image frames, for example, can be represented by a few still images of the layers plus six parameters per frame per layer" (col. 6, lines 55-57).

3. Independent claim 1

a. Introduction

Independent claim 1 recites:

> 1. A machine-implemented method of processing a sequence of image frames, comprising:

> computing respective sets of motion vectors for pairs of the image frames;
>
> classifying the computed motion vectors into motion classes;
>
> identifying motion clusters in the image frames based at least in part on the motion classes;
>
> determining for each of the identified motion clusters a respective spatiotemporal consistency value indicating persistence of the motion cluster in a respective spatial region across neighboring ones of the image frames;
>
> selecting one of the identified motion clusters as a motion stabilization reference based on the spatiotemporal consistency values;
>
> determining a motion model describing motion of the motion stabilization reference in the image frame sequence; and
>
> producing a motion-stabilized version of the sequence of image frames based on the motion model.

As explained in detail below, the rejection of independent claim 1 under 35 U.S.C. § 102(b) over Wang should be withdrawn because Wang neither expressly nor inherently discloses each and every element of the invention defined by the claim.

b. The Examiner's position

In support of the rejection of claim 1, the Examiner has taken the following position (see § 2 on pages 9-10 of the final Office action):

- the "computing respective sets of motion vectors for pairs of the image frames" element of claim 1 is disclosed by Wang in FIG. 3, blocks 20-22;
- the "classifying the computed motion vectors into motion classes" element of claim 1 is disclosed by Wang in FIGS. 3, 8A, 8B, col. 5, lines 15-67 "to column 6";
- the "identifying motion clusters in the image frames based at least in part on the motion classes" element of claim 1 is disclosed by Wang in FIGS. 3, 8A, 8B, col. 5, lines 15-67 "to column 6";
- the "determining … a respective spatiotemporal consistency value" element of claim 1 is disclosed by Wang in FIG. 4 ("where the image as a whole is map for identifying clusters of motion vectors"), FIG. 3 (which "discloses two image in

sequences and both of these images are process for local motion estimator, the two sequence images are seen as spatiotemporal due to their side to side sequencing where the local motion estimator process the outputting value"; and "part 24a is seen as the persistence of the motion cluster due to its function of processing coherent motion region estimator across the sequencing frame"), and FIG. 5 ("where the sequencing images are shown to be process in by the same spatial region");

- the "selecting one of the identified motion clusters as a motion stabilization reference based on the spatiotemporal consistency values" element of claim 1 is disclosed by Wang in FIG. 8A steps 42-46 ("where clusters of motion vectors are selected"); FIGS. 8A-8B (where "steps testing pixels again the models, where the models are seen as the references"); and FIG. 8B step 52 (where "the comparing of the pixel values to the model, where the models contain the spatiotemporal consistency value");
- the "determining a motion model describing motion of the motion stabilization reference in the image frame sequence" element of claim 1 is disclosed by Wang in FIGS. 8A-8B (where "steps testing pixels again the models, where the models are seen as the references") and FIG. 8A step 40 (where "frames i and i+1 , these are seen as image frame sequence") ; and
- the "producing a motion-stabilized version of the sequence of image frames based on the motion model" element of claim 1 is disclosed by Wang in FIGS. 8A, 8B, and col. 2, lines 45-55 ("where the process of the method will create a frame where the pixel assignments do not change significantly between iteration, this is seen as motion stable") and FIG. 8A (where "part 40 discloses the generating of a dense motion model").

With respect to claim 1, the Examiner's statements in the "Response to Arguments" section beginning on page 2 of the final Office action merely are restatements of the Examiner's position given in the "Claim Rejections" section beginning on page 8 of the final Office action.

c. <u>Appellant's rebuttal: Wang does not disclose each and every element of the invention defined in claim 1</u>

i. <u>Wang does not disclose the "determining ... a respective spatiotemporal consistency value" element of claim 1</u>

(a) <u>The Examiner has not established a *prima facie* case of anticipation</u>

On its face, the Examiner's position with respect to the "determining ... a respective spatiotemporal consistency value" element of claim 1 has failed to establish a *prima facie* case of

anticipation. In particular, the Examiner has not shown that Wang expressly or inherently discloses "determining for each of the identified motion clusters a respective spatiotemporal consistency value indicating persistence of the motion cluster in a respective spatial region across neighboring ones of the image frames." Instead, the Examiner merely has stated that Wang discloses (see § 2 on page 9 of the final Office action):

> ...determining for each of the identified motion clusters (figure 4 disclose where the image as a whole is map for identifying clusters of motion vectors) a respective spatiotemporal consistency value (figure 3 discloses two image in sequences and both of these images are process for local motion estimator, the two sequence images are seen as spatiotemporal due to their side to side sequencing where the local motion estimator process the outputting value) indicating persistence of the motion cluster (figure 3 part 24a is seen as the persistence of the motion cluster due to its function of processing coherent motion region estimator across the sequencing frame) in a respective spatial region (figure 5 discloses where the sequencing images are shown to be process in by the same spatial region) across neighboring ones of the image frames (figure 3 part 20, figure 5)...

None of the Examiner's statements in this regard constitutes a showing that Wang discloses "determining for each of the identified motion clusters a respective spatiotemporal consistency <u>value</u> indicating persistence of the motion cluster in a respective spatial region across neighboring ones of the image frames." Instead, the Examiner merely states that the two image frames i and 1+1 shown in FIG. 3, which are processed by the local motion estimator 22, "are seen as spatiotemporal." The Examiner's "viewing" of the processing of the consecutive image frames i and i+1 in parallel "as spatiotemporal" does not constitute a showing the Wang determines a respective spatiotemporal consistency <u>value</u> for each of the identified motion clusters.

For at least this reason, the rejection of independent claim 1 under 35 U.S.C. § 102(b) over Wang should be withdrawn.

(b) Moreover, Wang does not disclose the "determining ... a respective spatiotemporal consistency value" element of claim 1

Wang does not disclose "determining for each of the identified motion clusters a respective spatiotemporal consistency value indicating persistence of the motion cluster in a respective spatial region across neighboring ones of the image frames," as recited in claim 1.

As explained above, the Examiner has taken the position that Wang discloses this element of claim 1 in FIG. 4 ("where the image as a whole is map for identifying clusters of motion vectors"), FIG. 3 (which "discloses two image in sequences and both of these images are process for local motion estimator, the two sequence images are seen as spatiotemporal due to their side to side sequencing where the local motion estimator process the outputting value"; and "part 24a is seen as the persistence of the motion cluster due to its function of processing coherent motion region estimator across the sequencing frame"), and FIG. 5 ("where the sequencing images are shown to be process in by the same spatial region"). Contrary to the Examiner's position, however, none of the cited sections of Wang's disclosure involves "determining for each of the identified motion clusters a respective spatiotemporal consistency value indicating persistence of the motion cluster in a respective spatial region across neighboring ones of the image frames."

The Examiner's remarks in this regard suggest that he has misunderstood the processes that are performed by the local motion estimator 22 and the motion segmentation processor 24 components of Wang's encoder 12 (see FIG. 3). The following summary of these processes are provided for the benefit of the Board, as well as the Examiner.

(c) Summary of the processes performed by Wang's local motion estimator 22 and motion segmentation processor 24

The local motion estimator 22 generates motion vectors between local neighborhoods of pixels between consecutive image frames in a sequence (see col. 5, lines 16-23). The result is an optic flow or dense motion model of the image (see col. 7, lines 64-66; FIG. 4).

Based on the optic flow motion model (FIG. 4) produced by the local motion estimator 22, the motion segmentation processor 24 determines regions of coherent motion in an image and a set of motion models for the regions (see col. 5, lines 33-36). In this process, an affine

motion model estimator 32 (FIG. 7) component of the motion model estimator 24b (FIG. 3) starts with a regular grid of r rectangular blocks as a first estimate of coherent regions for frames 0 and 1 of the sequence (see col. 8, lines 3-13). The affine motion model estimator 32 models the motion within each of the r regions (see col. 8, lines 13-15). The affine motion model estimator 32 uses linear regression to produce estimates of affine motion parameters for the associated local motion vectors (see col. 8, lines 25-27). The affine motion model estimator 32 then determines the variance of the local motion vectors within each of the r regions (see col. 8, lines 45-49), and assigns to each motion model a respective confidence rating corresponding to the reciprocal of the variance (see col. 8, lines 49-51).

A clustering processor 34 (FIG. 7) component of the motion model estimator 24b uses a modified k-means clustering technique to group the r regions into C clusters (see col. 9, lines 7-10). The clustering processor 34 ignores clusters with a small number of regions and determines motion models for the remaining clusters based on a averaging of the affine motion models of their constituent regions (see col. 9, lines 10-17). The clustering processor 34 merges clusters that have similar motion models (col. 9, lines 18-21). After clustering, the clustering processor 34 sends the resulting $q \leq r$ affine motion models to a hypothesis tester 36 (FIG. 7), which is a component of the coherent motion region estimator 24a (see col. 9, lines 21-24).

The hypothesis tester 36 tests the pixels of the image frame individually against each of the motion models to determine the best pixel-to-model fit (see col. 9, lines 24-27). The hypothesis tester 36 segments the image frame pixel-by-pixel into q regions and one or more unassigned pixels (see col. 9, lines 41-43).

The affine motion model estimator 32 uses the q regions to determine updated affine parameters (see col. 9, lines 50-51). The clustering processor 34 and the hypothesis tester 36 respectively perform clustering and hypothesis testing based on the updated affine parameters (see col. 9, lines 51-55). This process is repeated until a convergence criterion is met (see col. 9, lines 55-63). After the regions of coherent motion are identified, the system extracts the corresponding layers using motion compensation (see col. 10, lines 59-61).

(d) Conclusion

Nowhere in the process described above do any of the local motion estimator 22 and the motion segmentation processor 24 components of Wang's encoder 12 determine "for each of the identified motion clusters a respective spatiotemporal consistency value indicating persistence of the motion cluster in a respective spatial region across neighboring ones of the image frames."

(e) Rebuttals to the Examiner's statements in support of his position

The following are specific rebuttals to the specific statements made by the Examiner with respect to the "determining ... a respective spatiotemporal consistency value" element of claim 1.

The Examiner has stated that "figure 4 discloses where the image as a whole is map for identifying clusters of motion vectors" (see § 2 on page 9 of the final Office action). FIG. 4 merely "depicts a dense motion model of a frame depicted in FIG. 1 (col. 4, lines 3-4). FIG. 4 does not expressly nor inherently disclose the "determining ... a respective spatiotemporal consistency value" element of claim 1. Instead, FIG. 4 shows a representation of motion vectors between local neighborhoods of pixels between consecutive image frames in a sequence (see col. 5, lines 16-23).

The Examiner has stated that "figure 3 discloses two image in sequences and both of these images are process for local motion estimator, the two sequence images are seen as spatiotemporal due to their side to side sequencing where the local motion estimator process the outputting value" (see § 2 on page 9 of the final Office action). FIG. 3 shows a block diagram of Wang's encoder 12 (see col. 5, lines 16-32). The "side to side sequencing" of the frames i and i+1 shown in FIG. 3 merely indicates that these two frames are processed in parallel by the local motion estimator 22 to generate the optic flow motion model shown in FIG. 4 (see col. 5, lines 16-23; col. 7, lines 64-66; FIG. 4). As explained above, none of the processes performed by the local motion estimator 22 and the motion segmentation processor 24 involves "determining for each of the identified motion clusters a respective spatiotemporal consistency value indicating persistence of the motion cluster in a respective spatial region across neighboring ones of the image frames," as recited in claim 1.

The Examiner has stated that "figure 3 part 24a is seen as the persistence of the motion cluster due to its function of processing coherent motion region estimator across the sequencing frame" (see § 2 on page 9 of the final Office action). The coherent motion region estimator 24a associates individual pixels with composite motion models by assigning each pixel to the motion model that most closely resembles the pixel's local motion (see col. 5, lines 43-47). In particular, the hypothesis tester 36 component of the coherent motion region estimator 24a (see FIG. 7) tests the pixels of the image frame individually against each of the motion models to determine the best pixel-to-model fit (see col. 9, lines 24-27). The hypothesis tester 36 segments the image frame pixel-by-pixel into q regions and one or more unassigned pixels (see col. 9, lines 41-43). The coherent motion region estimator 24a does not determine "for each of the identified motion clusters a respective spatiotemporal consistency value indicating persistence of the motion cluster in a respective spatial region across neighboring ones of the image frames," as recited in claim 1.

The Examiner has stated that "figure 5 discloses where the sequencing images are shown to be process in by the same spatial region" (see § 2 on page 9 of the final Office action). Appellant cannot decipher the intended meaning of this statement and requests clarification from the Examiner. As explained by Wang, "FIG. 5 illustrates pixel neighborhoods used in determining local motion" (col. 4, lines 5-6). Nowhere in Wang's description of the process by which the local motion estimator 22 determines local motion (see col. 6, line 57 - col. 8, line 2) does Wang even hint that this process involves "determining for each of the identified motion clusters a respective spatiotemporal consistency value indicating persistence of the motion cluster in a respective spatial region across neighboring ones of the image frames," as recited in claim 1.

ii. Wang does not disclose any of the "selecting" and "determining a motion model" elements of claim 1

Wang also does not disclose "selecting one of the identified motion clusters as a motion stabilization reference based on the spatiotemporal consistency values" nor does Wang disclose "determining a motion model describing motion of the motion stabilization reference in the image frame sequence," as recited in claim 1.

The Examiner has stated that Wang discloses "selecting an identified motion cluster as a motion stabilization reference" in FIGS. 3, 8A, and 8B and col. 5, line 15 - col. 6. Nowhere in this disclosure, however, does Wang teach that a motion cluster is selected as a motion stabilization reference. In pertinent part, this disclosure teaches that motion vectors and boundaries associated with regions of coherent motion are determined (see, e.g., col. 6, lines 45-47). None of the regions of coherent motion, however, is selected as a motion stabilization reference. Instead, Wang expressly teaches that each of these regions is extracted as a respective layer (see, e.g., col. 10, lines 59-67).

Moreover, since Wang's system does not perform motion stabilization, selecting a motion stabilization reference would not serve any useful purpose in the context of Wang's image compression system (see col. 1, lines 10-12). Moreover, the selection of a region of coherent motion (i.e., a moving object) as a motion stabilization reference would lead to undesirable motion compensation results (see, e.g., page 2, lines 7-11, of the specification of the instant application).

Since Wang does not disclose "selecting an identified motion cluster as a motion stabilization reference", Wang cannot possibly disclose "determining a motion model describing motion of the motion stabilization reference in the image frame sequence," as recited in claim 1.

<u>iii. Wang does not disclose the "producing" element of claim 1</u>

Wang also does not disclose "producing a motion-stabilized version of the sequence of image frames based on the motion model," as recited in claim 1.

As explained above, the Examiner has taken the position that Wang discloses this element of claim 1 in FIGS. 8A, 8B, and col. 2, lines 45-55 ("where the process of the method will create a frame where the pixel assignments do not change significantly between iteration, this is seen as motion stable") and in FIG. 8A (where "part 40 discloses the generating of a dense motion model"). Contrary to the Examiner's statement, however, Wang does not teaching anything about producing a motion-stabilized version of a sequence of image frames.

In FIGS. 8A and 8B, Wang discloses the operations that are performed by the encoder 12 in estimating motion models for successive frame pairs (see col. 9, lines 64-66). These

operations are described above in the section entitled "Summary of the processes performed by Wang's local motion estimator 22 and motion segmentation processor 24." As revealed by this description, the operations that are performed by the encoder 12 do not involve "producing a motion-stabilized version of the sequence of image frames based on the motion model." The "motion compensation" mentioned by Wang in connection with step 64 of FIG. 8B merely refers to the warping of the each of the regions of coherent motion to a common reference frame in the process of extracting the layers (see col. 10, lines 59 - col. 11, line 10).

In col. 2, lines 45-55, Wang merely summarizes the processes performed by the motion model estimator 24b and the coherent motion region estimator 24a. These processes are described above in the section entitled "Summary of the processes performed by Wang's local motion estimator 22 and motion segmentation processor 24." As revealed by this description, the operations that are performed by the encoder 12 do not involve "producing a motion-stabilized version of the sequence of image frames based on the motion model."

In step 40 of FIG. 8A, Wang merely discloses that the local motion estimator 22 estimates the local motion of pixels between frames i and i+1 to generate a dense motion model of the image (see col. 9, line 66 - col. 10, line 2). The process of generating the dense motion model does not involve "producing a motion-stabilized version of the sequence of image frames based on the motion model," as recited in claim 1.

4. Independent claim 11

Independent claim 11 recites:

> 11. A system for processing a sequence of image frames, comprising:
>
> a motion estimation module configured to compute respective sets of motion vectors for pairs of image frames;
>
> a motion classification module configured to classify the computed motion vectors into motion classes;
>
> a motion-based spatial clustering module configured to
>
> identify motion clusters in the image frames based at least in part on the motion classes, and

determine for each of the identified motion clusters a respective spatiotemporal consistency value indicating persistence of the motion cluster in a respective spatial region across neighboring ones of the image frames;

a motion stabilization reference selection module configured to select one of the identified motion clusters as a motion stabilization reference based on the spatiotemporal consistency values; and

a motion stabilization module configured to

determine a motion model describing motion of the motion stabilization reference in the image frame sequence, and

produce a motion-stabilized version of the sequence of image frames based on the motion model.

Independent claim 11 recites features that essentially track the pertinent features of independent claim 1 discussed above. Therefore, claim 11 is patentable over Wang for at least the same reasons explained above in connection with claim 1. In particular, the rejection of independent claim 11 under 35 U.S.C. § 102(b) over Wang should be withdrawn because Wang neither expressly nor inherently discloses any of:

- a motion-based spatial clustering module configured to ... determine for each of the identified motion clusters a respective spatiotemporal consistency value indicating persistence of the motion cluster in a respective spatial region across neighboring ones of the image frames;
- a motion stabilization reference selection module configured to select one of the identified motion clusters as a motion stabilization reference based on the spatiotemporal consistency values; and
- a motion stabilization module configured to determine a motion model describing motion of the motion stabilization reference in the image frame sequence, and produce a motion-stabilized version of the sequence of image frames based on the motion model.

5. Independent claim 21

Independent claim 21 recites:

> 21. Claim 21 (previously presented): A machine-readable medium storing machine-readable instructions for causing a machine to perform operations comprising:
>
> computing respective sets of motion vectors for pairs of image frames;
>
> classifying the computed motion vectors into motion classes;
>
> identifying motion clusters in the image frames based at least in part on the motion classes;
>
> determining for each of the identified motion clusters a respective spatiotemporal consistency value indicating persistence of the motion cluster in a respective spatial region across neighboring ones of the image frames;
>
> selecting one of the identified motion clusters as a motion stabilization reference based on the spatiotemporal consistency values;
>
> determining a motion model describing motion of the motion stabilization reference in the image frame sequence; and
>
> producing a motion-stabilized version of the sequence of image frames based on the motion model.

Independent claim 21 recites features that essentially track the pertinent features of independent claim 1 discussed above. Therefore, claim 21 is patentable over Wang for at least the same reasons explained above in connection with claim 1. In particular, the rejection of independent claim 21 under 35 U.S.C. § 102(b) over Wang should be withdrawn because Wang neither expressly nor inherently discloses any of the "determining … a respective spatiotemporal consistency value," "selecting," "determining a motion model," and "producing" elements of claim 21.

B. Claims 8, 9, 18, 19, 28, and 29 stand rejected under 35 U.S.C. § 103(a) over Wang in view of Heisele

The Examiner has rejected claims 8, 9, 18, 19, 28, and 29 under 35 U.S.C. § 103(a) over Wang in view of Heisele ("Motion-based object detection and tracking in color image sequence").

1. Applicable standards for sustaining a rejection under 35 U.S.C. § 103(a)

"A patent may not be obtained ... if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains." 35 U.S.C. §103(a).

In an appeal involving a rejection under 35 U.S.C. § 103, an examiner bears the initial burden of establishing *prima facie* obviousness. See In re Rijckaert, 9 F.3d 1531, 1532, 28 USPQ2d 1955, 1956 (Fed. Cir. 1993). To support a *prima facie* conclusion of obviousness, the prior art must disclose or suggest all the limitations of the claimed invention.[1] See In re Lowry, 32 F.3d 1579, 1582, 32 USPQ2d 1 031, 1034 (Fed. Cir. 1994). If the examiner has established a *prima facie* case of obviousness, the burden of going forward then shifts to the applicant to overcome the *prima facie* case with argument and/or evidence. Obviousness, is then determined on the basis of the evidence as a whole and the relative persuasiveness of the arguments. This inquiry requires (a) determining the scope and contents of the prior art; (b) ascertaining the differences between the prior art and the claims in issue; (c) resolving the level of ordinary skill in the pertinent art; and (d) evaluating evidence of secondary consideration. See KSR Int'l Co. v.

[1] The U.S. Patent and Trademark Office has set forth the following definition of the requirements for establishing a *prima facie* case of unpatentability (37 CFR § 1.56(b)(ii):

> A prima facie case of unpatentability is established when the information compels a conclusion that a claim is unpatentable under the preponderance of evidence, burden-of-proof standard, giving each term in the claim its broadest reasonable construction consistent with the specification, and before any consideration is given to evidence which may be submitted in an attempt to establish a contrary conclusion of patentability.

Teleflex Inc., No. 04-1350, slip op. at 2 (U.S. Apr. 30, 2007) (citing Graham v. John Deere, 383 U.S. I, 17-18, 148 USPQ 459, 467 (1966)). If all claim limitations are found in a number of prior art references, the fact finder must determine whether there was an apparent reason to combine the known elements in the fashion claimed. See KSR, slip op. at 14. This analysis should be made explicit. KSR, slip op at 14 (citing In re Kahn, 441 F. 3d 977, 988 (CA Fed. 2006): "[R]ejections on obviousness grounds cannot be sustained by mere conclusory statements; instead, there must be some articulated reasoning with some rational underpinning to support the legal conclusion of obviousness").

2. Dependent claims 8 and 9

a. Introduction

Each of claims 8 and 9 incorporates the features of independent claim 1. Heisele does not make-up for the failure of Wang to disclose or suggest the elements of independent claim 1 discussed above. Therefore claims 8 and 9 are patentable over Wang in view of Heisele for at least the same reasons explained above in connection with in independent claim 1.

Each of claims 8 and 9 also is patentable over Wang in view of Heisele for the following additional reasons.

b. Dependent claim 8

Claim 8 depends from claim 1 and recites that "the selecting comprises projecting each motion cluster from image frames to respective neighboring image frames, and computing respective measures of spatiotemporal consistency for the projected motion clusters."

In support of the rejection of claims 8, 18, and 28, the Examiner has stated that:

> ...Heisele in the same field of endeavor disclose wherein selecting a motion cluster as a motion stabilization reference comprises projecting each motion cluster from image frames to respective neighboring image frames, and computing respective measures of spatiotemporal consistency for the projected motion clusters (page 2 left column lines 23. A consistent segmentation results over time is seen as the reference motion cluster over the image frames.).

Contrary to the Examiner's statement, however, the mere statement that "we obtain consistent segmentation results over time" does not constitute a teaching that Heisele selects a motion cluster as a motion stabilization reference. Indeed, performing object segmentation does not involve selecting a motion cluster as a motion stabilization reference. The fact is that Heisele's system does not perform motion stabilization and, therefore, selecting a motion stabilization reference would not serve any useful purpose. In response to this point, the Examiner has stated that (see page 6, sixth ¶):

> Examiner's response - Combing Wang and Heisele teaches the concept of computing for motion stabilization (column 2 lines 45-55 teaches where the process of the method will create a frame where the pixel assignments do not change significantly between iteration, this is seen as motion stable and compensation) and, therefore, selecting a motion stabilization reference (figure 3 teaches where sequence images are process to find coherency in development of a motion model and the model is seen as reference where pixels are compare to).

By pointing only to sections of Wang's disclosure, the Examiner implicitly has conceded that Heisele does not disclose or suggest anything about selecting a motion stabilization reference. Therefore, Heisele cannot possibly disclose that selecting a motion stabilization reference "comprises projecting each motion cluster from image frames to respective neighboring image frames, and computing respective measures of spatiotemporal consistency for the projected motion clusters," as recited in claim 8. Since neither Wang (see page 11, § 4, ¶¶ 2-4 of the final Office action) nor Heisele discloses the elements of claim 8, the Examiner's proposed combination of Wang and Heisele cannot possibly disclose these elements.

In the response quoted above, the Examiner has stated that "column 2 lines 45-55 teaches where the process of the method will create a frame where the pixel assignments do not change significantly between iteration, this is seen as motion stable and compensation." In col. 2, lines 45-55, Wang merely summarizes the processes performed by the motion model estimator 24b and the coherent motion region estimator 24a. These processes are described above in the section entitled "Summary of the processes performed by Wang's local motion estimator 22 and motion segmentation processor 24." As revealed by this description, the operations that are

performed by the encoder 12 do not involve "producing a motion-stabilized version of the sequence of image frames based on the motion model."

In the response quoted above, the Examiner also has stated that "figure 3 teaches where sequence images are process to find coherency in development of a motion model and the model is seen as reference where pixels are compare to." FIG. 3 shows a block diagram of Wang's image encoder 12. As explained above in the section entitled "Summary of the processes performed by Wang's local motion estimator 22 and motion segmentation processor 24," the process by which the image encoder 12 determines regions of coherent motion does not involve "projecting each motion cluster from image frames to respective neighboring image frames, and computing respective measures of spatiotemporal consistency for the projected motion clusters," as recited in claim 8.

In support of the rejection of claim 8, the Examiner also has not pointed to any disclosure in Heisele that supports the statement that Heisele discloses "computing respective measures of spatiotemporal consistency for the projected motion clusters." In response to Appellant's request for the Examiner to point to a specific location in Heisele that discloses "computing respective measures of spatiotemporal consistency for the projected motion clusters," the Examiner has stated that (see page 7, third ¶ of the final Office action):

> Examiner's response - The combine teaches of Wang and Heisele teaches the concept of computing respective measures (Wang, figure 3 part 24a teaches the respective measure by coherent motion processing) of spatiotemporal consistency (figure 3 part 20 disclose processing of sequence images, these are the consistency) for the projected motion clusters (figure 3 part 22 disclose the locating the local motions in the image).

By pointing only to sections of Wang's disclosure, the Examiner implicitly has conceded that Heisele does not disclose or suggest anything about "computing respective measures of spatiotemporal consistency for the projected motion clusters," as recited in claim 8. Since neither Wang (see page 11, § 4, ¶¶ 2-4 of the final Office action) nor Heisele discloses the elements of claim 8, the Examiner's proposed combination of Wang and Heisele cannot possibly disclose these elements.

In the second response quoted above, the Examiner has reiterated various assertions regarding the contents of Wang's disclosure. These assertions have been rebutted above in connection with the rejection of independent claim 1 (see § VII.A.3 of this Appeal Brief).

c. Dependent claim 9

Claim 9 depends from claim 1 and recites that "the selecting comprises selecting as the motion stabilization reference for a given reference image frame the motion cluster having a greater spatiotemporal consistency value than the spatiotemporal consistency values of other ones of the motion clusters across multiple image frames neighboring the given reference image frame."

In support of the rejection of claims 9, 19, and 29, the Examiner has stated that:

> ...Heisele in the same field of endeavor disclose wherein the motion cluster selected as a motion stabilization reference for a given reference image frame has a greater spatiotemporal consistency measure than other motion clusters across multiple image frames neighboring the given reference image frame (page one, right column lines 14-25. Even with the reduction of data from this method it stills generate more motion data across the images.).

In the section cited by the Examiner, Heisele merely describes techniques for estimating motion based on tracking image features over a sequence of images and that tracking colored regions determined by color segmentation yields good results. Contrary to the Examiner's statement, the cited section of Heisele's disclosure does not disclose that the motion cluster selected as a motion stabilization reference for a given reference image frame has a greater spatiotemporal consistency measure than other motion clusters across multiple image frames neighboring the given reference image frame. Indeed, neither the section cited by the Examiner in support of the rejection of claim 9 nor any other section of Heisele discloses or suggests the elements of claim 9. The fact is that Heisele's system does not perform motion stabilization and, therefore, selecting a motion stabilization reference would not serve any useful purpose.

Although the above point was raised in the Amendment dated June 1, 2007 (see page 13, ¶¶ 3-5), the Examiner did not provide any response in the final Office action that addressed this point.

3. Dependent claims 18 and 19

a. Introduction

Each of claims 18 and 19 incorporates the features of independent claim 11. Heisele does not make-up for the failure of Wang to disclose or suggest the elements of independent claim 11 discussed above. Therefore claims 18 and 19 are patentable over Wang in view of Heisele for at least the same reasons explained above in connection with in independent claim 11

Each of claims 18 and 19 also is patentable over Wang in view of Heisele for the following additional reasons.

b. Dependent claim 18

Dependent claim 18 recites elements that essentially track the pertinent elements of claim 8 discussed above. Therefore claim 18 is patentable over Wang in view of Heisele for at least the same reasons explained above in connection with claim 8.

c. Dependent claim 19

Dependent claim 19 recites elements that essentially track the pertinent elements of claim 9 discussed above. Therefore claim 19 is patentable over Wang in view of Heisele for at least the same reasons explained above in connection with claim 9.

4. Dependent claims 28 and 29

a. Introduction

Each of claims 28 and 29 incorporates the features of independent claim 21. Heisele does not make-up for the failure of Wang to disclose or suggest the elements of independent claim 21

discussed above. Therefore claims 28 and 29 are patentable over Wang in view of Heisele for at least the same reasons explained above in connection with in independent claim 21

Each of claims 28 and 29 also is patentable over Wang in view of Heisele for the following additional reasons.

b. Dependent claim 28

Dependent claim 28 recites elements that essentially track the pertinent elements of claim 8 discussed above. Therefore claim 28 is patentable over Wang in view of Heisele for at least the same reasons explained above in connection with claim 8.

c. Dependent claim 29

Dependent claim 29 recites elements that essentially track the pertinent elements of claim 9 discussed above. Therefore claim 29 is patentable over Wang in view of Heisele for at least the same reasons explained above in connection with claim 9.

C. Claims 2-6, 12-16, and 22-26 stand rejected under 35 U.S.C. § 103(a) over Wang in view of Ohm

The Examiner has rejected claims 2-6, 12-16, and 22-26 under 35 U.S.C. § 103(a) over Wang in view of Ohm ("Feature-based cluster segmentation of image sequences").

1. Dependent claims 2-6

Each of claims 2-6 incorporates the features of independent claim 1. Ohm does not make-up for the failure of Wang to disclose or suggest the elements of independent claim 1 discussed above. Therefore claims 2-6 are patentable over Wang and Ohm for at least the same reasons explained above in connection with in independent claim 1.

Claim 6 also is patentable over Wang and Ohm for the following additional reasons.

Claim 6 depends from claim 4 and recites that "ones of the motion vectors are re-classified with a modified clustering parameter in response to a determination that the respective spatiotemporal consistency values are below a consistency threshold."

In support of the rejection of claims 6, 16, and 26, the Examiner has stated that:

> ... Ohm in the same field of endeavor disclose wherein motion vectors are re-classified with a modified clustering parameter in response to a determination that a computed spatiotemporal consistency measure is below a consistency threshold (figure 2 of page 3, page 3 paragraph "4 Segment merging based on local feature analysis" and "5 Segment tracking").

Contrary to the Examiner's statement, however, Ohm does not disclose that "motion vectors are re-classified with a modified clustering parameter in response to a determination that a computed spatiotemporal consistency measure is below a consistency threshold."

In FIG. 2, Ohm discloses the

> ...use [of] the forward motion vectors (same as used for local feature classification) to project a segment belonging to the foreground object at time t to the next frame at time t+1. Find segment(s) with the same label in the next frame, which are at any position overlapping with the projected segment... (Page 3, col. 1, § 5, line 6 - page 3, col. 2, line 4)

This disclosure does not disclose or suggest anything about reclassifying motion vectors with a modified clustering parameter in response to a determination that a computed spatiotemporal consistency measure is below a consistency threshold. Instead, this disclosure merely teaches that segment tracking can be performed based on cluster labels. The process described in connection with FIG. 2 is performed <u>after</u> the segments already have been finally identified in each image and, therefore, does not involve re-classifying motion vectors with a modified clustering parameter. Thus, FIG. 2 does not disclose that "ones of the motion vectors are re-classified with a modified clustering parameter in response to a determination that the respective spatiotemporal consistency values are below a consistency threshold."

On page 3, § 4, Ohm discloses

> Though the application of variable weighting to the motion feature results in relatively large segments, if object motion is homogeneous, there remain patches of small segments that cannot uniquely be allocated to object or background. These can be

> handled by a segment merging procedure, which is based on local feature analysis. The local feature analysis calculates the centroid according to (3), but only inside one individual segment. This is performed separately for the motion and color features. Segments can be merged, if either the difference in the motion feature is small and the motion is reliable for this segment, or if the difference in the color feature is small.

This disclosure does not disclose or suggest anything about reclassifying motion vectors with a modified clustering parameter in response to a determination that a computed spatiotemporal consistency measure is below a consistency threshold.

In response to these points, the Examiner has stated that (see page 7, last ¶ of the final Office action):

> Examiner's response - Ohms teaches motion vectors (page 1 paragraph Introduction discloses motion vector field determination of the image) are re-c1assified with a modified clustering parameter (page 3 figure 2 discloses in part B where modified clusters by those that are retained and those that are eliminated) in response to a determination that a computed spatiotemporal consistency (page 3 figure 2 part A disclose frame t to frame t+1, where the image process takes place) measure is below a consistency threshold (page 3 paragraph 4-5 discloses where the threshold of 50% overlap requirement, this is seen as a consistency threshold value).

In FIG. 2a, Ohm shows the projection of various segments from frame t into frame t+1. In FIG. 2b, Ohm shows how a segment found in frame t+1 is classified as the correctly-tracked segment if it has at least 50% overlap with segments of the same index projected from frame t (see page 3, second ¶). As explained above, the process described in connection with FIG. 2 is performed <u>after</u> the segments already have been finally identified in each image and, therefore, does not involve re-classifying motion vectors with a modified clustering parameter. Thus, FIG. 2 does not disclose that "ones of the motion vectors are re-classified with a modified clustering parameter in response to a determination that the respective spatiotemporal consistency values are below a consistency threshold."

Regarding the disclosure on page 3 relating to the "50% overlap requirement," Ohm merely discloses that a segment found in frame t+1 is classified as the correctly-tracked segment if it has at least 50% overlap with segments of the same index projected from frame t (see page 3, second ¶). This process is performed <u>after</u> the segments already have been finally identified in each image and, therefore, does not involve re-classifying motion vectors with a modified clustering parameter. Thus, the section of Ohm cited by Ohm in support of the rejection of claim 6 does not disclose that "ones of the motion vectors are re-classified with a modified clustering parameter in response to a determination that the respective spatiotemporal consistency values are below a consistency threshold."

2. Dependent claims 12-16

Each of claims 12-16 incorporates the features of independent claim 11. Ohm does not make-up for the failure of Wang to disclose or suggest the elements of independent claim 11 discussed above. Therefore claims 12-16 are patentable over Wang and Ohm for at least the same reasons explained above in connection with in independent claim 11.

Claim 16 also is patentable over Wang and Ohm for the following additional reasons.

Dependent claim 16 recites elements that essentially track the pertinent elements of claim 6discussed above. Therefore claim 16 is patentable over Wang in view of Ohm for at least the same reasons explained above in connection with claim 6.

3. Dependent claims 22-26

Each of claims 22-26 incorporates the features of independent claim 21. Ohm does not make-up for the failure of Wang to disclose or suggest the elements of independent claim 21 discussed above. Therefore claims 22-26 are patentable over Wang and Ohm for at least the same reasons explained above in connection with in independent claim 21.

Claim 26 also is patentable over Wang and Ohm for the following additional reasons.

Dependent claim 26 recites elements that essentially track the pertinent elements of claim 6discussed above. Therefore claim 26 is patentable over Wang in view of Ohm for at least the same reasons explained above in connection with claim 6.

D. Claims 7, 17, and 27 stand rejected under 35 U.S.C. § 103(a) over Wang in view of Ohm and Heisele

The Examiner has rejected claims 7, 17, and 27 under 35 U.S.C. § 103(a) over Wang in view of Ohm and Heisele.

Claim 7 incorporates the features of independent claim 1; claim 17 incorporates the features of independent claim 11; and claim 27 incorporates the features of independent claim 21. As explained above, neither Heisele nor Ohm makes-up for the failure of Wang to teach or suggest the elements of independent claims 1, 11, and 21 discussed above. Therefore, claims 7, 17, and 27 are patentable over Wang, Ohm, and Heisele for at least the same reasons explained above.

VIII. Conclusion

For the reasons explained above, all of the pending claims are now in condition for allowance and should be allowed.

Charge any excess fees or apply any credits to Deposit Account No. 08-2025.

Respectfully submitted,

Date: March 4, 2008

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CLAIMS APPENDIX

The claims that are the subject of Appeal are presented below.

Claim 1 (previously presented): A machine-implemented method of processing a sequence of image frames, comprising:

computing respective sets of motion vectors for pairs of the image frames;

classifying the computed motion vectors into motion classes;

identifying motion clusters in the image frames based at least in part on the motion classes;

determining for each of the identified motion clusters a respective spatiotemporal consistency value indicating persistence of the motion cluster in a respective spatial region across neighboring ones of the image frames;

selecting one of the identified motion clusters as a motion stabilization reference based on the spatiotemporal consistency values;

determining a motion model describing motion of the motion stabilization reference in the image frame sequence; and

producing a motion-stabilized version of the sequence of image frames based on the motion model.

Claim 2 (previously presented): The method of claim 1, wherein the computing comprises generating for pairs of the image frames respective dense motion models describing motion at pixel locations with respective sets of parameter values in a motion parameter space.

Claim 3 (previously presented): The method of claim 2, wherein the identifying comprises iteratively clustering ones of the motion vectors from a coarse image frame resolution level to a fine image frame resolution level.

Claim 4 (previously presented): The method of claim 3, wherein at each image frame resolution level ones of the motion vectors are classified into motion clusters, and a respective

one of the spatiotemporal consistency values is determined for each of the clusters identified in a given image frame based on a projection of the motion cluster into a neighboring image frame using computed inter-frame motion.

Claim 5 (previously presented): The method of claim 4, wherein each of the respective spatiotemporal consistency values is determined based on degree of overlap between the respective motion cluster projected from the given image frame and a corresponding one of the motion clusters identified in the neighboring image frame.

Claim 6 (previously presented): The method of claim 4, wherein ones of the motion vectors are re-classified with a modified clustering parameter in response to a determination that the respective spatiotemporal consistency values are below a consistency threshold.

Claim 7 (original): The method of claim 3, wherein motion vectors are clustered iteratively in accordance with a clustering method.

Claim 8 (previously presented): The method of claim 1, wherein the selecting comprises projecting each motion cluster from image frames to respective neighboring image frames, and computing respective measures of spatiotemporal consistency for the projected motion clusters.

Claim 9 (previously presented): The method of claim 1, wherein the selecting comprises selecting as the motion stabilization reference for a given reference image frame the motion cluster having a greater spatiotemporal consistency value than the spatiotemporal consistency values of other ones of the motion clusters across multiple image frames neighboring the given reference image frame.

Claim 10 (canceled)

Claim 11 (previously presented): A system for processing a sequence of image frames, comprising:

a motion estimation module configured to compute respective sets of motion vectors for pairs of image frames;

a motion classification module configured to classify the computed motion vectors into motion classes;

a motion-based spatial clustering module configured to

identify motion clusters in the image frames based at least in part on the motion classes, and

determine for each of the identified motion clusters a respective spatiotemporal consistency value indicating persistence of the motion cluster in a respective spatial region across neighboring ones of the image frames;

a motion stabilization reference selection module configured to select one of the identified motion clusters as a motion stabilization reference based on the spatiotemporal consistency values; and

a motion stabilization module configured to

determine a motion model describing motion of the motion stabilization reference in the image frame sequence, and

produce a motion-stabilized version of the sequence of image frames based on the motion model.

Claim 12 (previously presented): The system of claim 11, wherein the motion estimation module is configured to compute motion vectors by generating for pairs of the image frames respective dense motion models describing motion at pixel locations with respective sets of parameter values in a motion parameter space.

Claim 13 (previously presented): The system of claim 12, wherein the motion-based spatial clustering module is configured to identify motion clusters by iteratively clustering ones of the motion vectors from a coarse image frame resolution level to a fine image frame resolution level.

Claim 14 (previously presented): The system of claim 13, wherein at each image frame resolution level ones of the motion vectors are classified by the motion classification module into motion clusters, and a respective one of the spatiotemporal consistency values is determined for each of the clusters in a given image frame based on a projection of the motion cluster into a neighboring image frame using computed inter-frame motion.

Claim 15 (previously presented): The system of claim 14, wherein each of the respective spatiotemporal consistency values is determined based on degree of overlap between the respective motion cluster projected from the given image frame and a corresponding one of the motion clusters identified in the neighboring image frame.

Claim 16 (previously presented): The system of claim 14, wherein the motion classification module re-classifies ones of the motion vectors with a modified clustering parameter in response to a determination that the respective spatiotemporal consistency values are below a consistency threshold.

Claim 17 (original): The system of claim 13, wherein the motion classification module clusters motion vectors iteratively in accordance with a clustering method.

Claim 18 (previously presented): The system of claim 11, wherein the motion stabilization reference selection module selects a motion cluster as the motion stabilization reference by projecting each motion cluster from image frames to respective neighboring image frames and computing respective measures of spatiotemporal consistency for the projected motion clusters.

Claim 19 (previously presented): The system of claim 11, wherein the motion stabilization reference selection module selects as the motion stabilization reference for a given reference image frame the motion cluster having a greater spatiotemporal consistency value than the spatiotemporal consistency values of other ones of the motion clusters across multiple image frames neighboring the given reference image frame.

Claim 20 (canceled)

Claim 21 (previously presented): A machine-readable medium storing machine-readable instructions for causing a machine to perform operations comprising:

computing respective sets of motion vectors for pairs of image frames;

classifying the computed motion vectors into motion classes;

identifying motion clusters in the image frames based at least in part on the motion classes;

determining for each of the identified motion clusters a respective spatiotemporal consistency value indicating persistence of the motion cluster in a respective spatial region across neighboring ones of the image frames;

selecting one of the identified motion clusters as a motion stabilization reference based on the spatiotemporal consistency values;

determining a motion model describing motion of the motion stabilization reference in the image frame sequence; and

producing a motion-stabilized version of the sequence of image frames based on the motion model.

Claim 22 (previously presented): The machine-readable medium of claim 21, wherein the machine-readable instructions cause the machine to compute motion vectors by generating for pairs of the image frames respective dense motion models describing motion at pixel locations with respective sets of parameter values in a motion parameter space.

Claim 23 (previously presented): The machine-readable medium of claim 22, wherein the machine-readable instructions cause the machine to identify motion clusters by iteratively clustering ones of the motion vectors from a coarse image frame resolution level to a fine image frame resolution level.

Claim 24 (previously presented): The machine-readable medium of claim 23, wherein at each image frame resolution level ones of the motion vectors are classified into motion clusters, and a respective one of the spatiotemporal consistency values is determined for each of the clusters in a given image frame based on a projection of the motion cluster into a neighboring image frame using computed inter-frame motion.

Claim 25 (previously presented): The machine-readable medium of claim 24, wherein each of the respective spatiotemporal consistency values is determined based on degree of overlap between the respective motion cluster projected from the given image frame and a corresponding one of the motion clusters identified in the neighboring image frame.

Claim 26 (previously presented): The machine-readable medium of claim 24, wherein the machine-readable instructions cause the machine to re-classify ones of the motion vectors with a modified clustering parameter in response to a determination that the respective spatiotemporal consistency values are below a consistency threshold.

Claim 27 (original): The machine-readable medium of claim 23, wherein the machine-readable instructions cause the machine to cluster motion vectors iteratively in accordance with a clustering method.

Claim 28 (previously presented): The machine-readable medium of claim 21, wherein the machine-readable instructions cause the machine to select a motion cluster as the motion stabilization reference by projecting each motion cluster from image frames to respective neighboring image frames and computing respective measures of spatiotemporal consistency for the projected motion clusters.

Claim 29 (previously presented): The machine-readable medium of claim 21, wherein the machine-readable instructions cause the machine to select as the motion stabilization reference for a given reference image frame the motion cluster having a greater spatiotemporal

consistency value than the spatiotemporal consistency values of other ones of the motion clusters across multiple image frames neighboring the given reference image frame.

Claim 30 (canceled)

EVIDENCE APPENDIX

There is no evidence submitted pursuant to 37 CFR §§ 1.130, 1.131, or 1.132 or any other evidence entered by the Examiner and relied upon by Appellant in the pending appeal. Therefore, no copies are required under 37 CFR § 41.37(c)(1)(ix) in the pending appeal.

RELATED PROCEEDINGS APPENDIX

Appellant is not aware of any decisions rendered by a court or the Board that will directly affect or be directly affected by or have a bearing on the Board's decision in the pending appeal. Therefore, no copies are required under 37 CFR § 41.37(c)(1)(x) in the pending appeal.